IN THE CLAIMS:

Please amend the claims as follows:

Claim 1[[,]]. (currently amended) A method for ~~the characteristics of the~~ rate distortion optimization (RDO) based rate control ~~scheme include~~ comprising:

Step 1: ~~Does~~ performing bit allocation for every picture in a GOP which includes an I frame, a P frame, or a B frame, and based on the allocated bits a predicted quantization parameter being ~~is~~ used to do a first rate distortion optimization mode selection for every macroblock in the current picture[[;]], wherein the predicted quantization parameter is the quantization parameter of a previous macroblock, and a coding mode minimizing the following formula is selected as the initial coding mode for the current macroblock:

$$D(s,c,MODE \mid QP) + \lambda_{MODE} R(s,c,MODE \mid QP)$$

wherein s is the luma value of the original macroblock, c is the luma value of the reconstructed macroblock, λ_{MODE} is the lagrangian constant;

for I/P frame, $\lambda_{MODE} = 0.85 \times 2^{Q_{m-1}/3}$;

for B frame, $\lambda_{MODE} = 4 \times 0.85 \times 2^{Q_{m-1}/3}$;

$D(s,c,MODE|QP)$ is used to evaluate the distortion of the current macroblock after it is coded with mode $MODE$;

$R(s,c,MODE|QP)$ is the bits used to code the macroblock with mode $MODE$;

QP is a quantization parameter for the current macroblock, and is equal to the predicted quantization parameter in the first rate distortion mode selection;

Step 2: ~~The~~ the information collected from the first rate distortion mode selection being ~~is~~ used to calculate a final quantization parameter for rate control, and if the final quantization parameter is different from the predicted, a second rate distortion mode selection will be executed again.

Claim 2[[,]]. (currently amended) The method of ~~as~~ claim 1 ~~has said~~, wherein in step 1, before coding a GOP, ~~does~~ bit allocation for the pictures in the GOP with the average picture size is performed[[;]].

Claim 3[[,]]. (currently amended) The method of ~~as~~ claim 2 ~~has said~~, wherein the average

picture size is calculated as:

$R/F = R \div F$, here, R is the target bit rate. F is the picture rate. R/F is the average picture size.

Claim 4[[,]]. (currently amended) The method of ~~as~~ claim 1 ~~and claim 2 have said~~, further comprising performing ~~does~~ bit allocation adjustment in the coded GOP[[.]], wherein the ~~The~~ adjustment is implemented as follows:

$$T_i = \max\left\{\frac{R}{1+\frac{N_p X_p}{K_p X_i}+\frac{N_b X_b}{K_b X_i}}, \frac{bit\_rate}{8\times picture\_rate}\right\}$$

$$T_p = \max\left\{\frac{R}{N_p+\frac{N_b K_p X_b}{K_b X_p}}, \frac{bit\_rate}{8\times picture\_rate}\right\}$$

$$T_b = \max\left\{\frac{R}{N_b+\frac{N_p K_b X_p}{K_p X_b}}, \frac{bit\_rate}{8\times picture\_rate}\right\}$$

here, T_I, T_p and T_b is the bits allocated to the I, P or B frame respectively[[.]]; N_i, N_p and N_b is the remained none coded I, P or B frames in the GOP respectively[[.]]; X_i, X_p and X_b is the global complexity estimation for the I, P or B frame respectively and is defined as the multiplier between coded bits and average quantization parameter for the frame[[.]];

bit_rate is the target bit rate[[.]], *picture_rate* is the frame rate[[.]];

K_p and K_b are constants[[.]], K_p, K_b means the complexity ratio between P, B frame and I frame respectively[[.]];

R is the remained bits for the GOP, and after coding a picture it is updated as follows:

$R = R\text{-}S_{i,p,b}$

$S_{i,p,b}$ is the coded bits for the current frame.

Claim 5[[,]]. (currently amended) The method of ~~as~~ claim 4 ~~has said~~, wherein before coding a GOP, the remaining bits for the current GOP is initialized as follows:

$R = G + R_{prev}$

$$G = bit\_rate \times N \div picture\_rate$$

here, R is the remained bits for the current GOP[[.]];

N is the number of frames in the current GOP[[.]];

G is the number of bits for a GOP[[.]];

R_{prev} is the remained bits for the previous GOP[[.]], for ~~For~~ the first GOP, R_{prev}=0.

Claim 6[[,]]. (currently amended) The method of ~~as~~ claim 4 ~~has said~~, wherein X_i、 X_p and X_b are initialized as:

$$X_i = a \times bit\_rate$$

$$X_p = b \times bit\_rate$$

$$X_b = c \times bit\_rate$$

here a, b and c are constants[[.]];

bit_rate is the target bitrate.

Claim 7. (canceled).

Claim 8[[,]]. (currently amended) The method of ~~as~~ claim [[7]] 1 ~~has said~~, wherein for motion estimation in P or B frame, the motion vector minimizing following expression is selected as the motion vector for the current macroblock:

$$J(\mathrm{m}, \lambda_{MOTION}) = SA(T)D(s, c(\mathrm{m})) + \lambda_{MOTION} R(\mathrm{m} - \mathrm{p})$$

here, $D(s,c(m))$ is used to evaluate the distortion from motion compensation[[.]];

$SA(T)D$ is the sum of the absolute difference after prediction (or after Hadmard transform) for the macroblock[[.]];

$R(m-p)$ is the bits used to code the motion vector[[.]];

s is the luma value of the current macroblock in the original frame[[.]];

c is the luma value in reference picture[[.]];

m is the motion vector[[.]];

p is the predicted motion vector[[.]];

λ_{MOTION} is the lagrangian constant and $\lambda_{MOTION} = \sqrt{\lambda_{MODE}}$ [[.]];

λ_{MODE} is the lagrangian constant.

Claim 9[[,]]. (currently amended) The method of ~~as~~ claim 2 ~~has said~~, wherein after the first rate distortion mode selection, the RDO based rate control further includes: calculating quantization parameter for the current macroblock[[.]]; ~~The~~ the quantization parameter is adjusted according to the macroblock activity and buffer status.

Claim 10[[,]]. (currently amended) The method of ~~as~~ claim 9 ~~has said~~, wherein the quantization parameter for the macroblock is adjusted according to the macroblock activity[[.]]; ~~After~~ after the first rate distortion mode selection, the sum of the absolute difference is used as the macroblock activity estimation[[.]]; ~~The~~ the macroblock activity is calculated as:

$$act_m = \sum_{i,j} |s(i,j) - c(i,j)| \quad N\_act_m = \frac{(2 \times act_j) + avg\_act}{act_j + (2 \times avg\_act)}$$

here, i is the horizontal position of the pixel in the current macroblock[[.]]; j is the vertical position of the pixel in the current macroblock[[.]]; N_act_m is the activity of the current macroblock[[.]]; $s(i,j)$ is the luma value of the original pixel(i, j), $c(i, j)$ is the prediction value of pixel(i, j)[[.]]; avg_act is the average act_m in the previous coded picture which is coded with the same type as current picture[[.]]; act_m is the sum of the absolute difference after motion compensation or intra prediction.

Claim 11[[,]]. (currently amended) The method of ~~as~~ claim 9 ~~has said~~, wherein a virtual buffer is used to do rate control[[.]]; ~~First~~ first set up the mapping from the virtual buffer occupancy to macroblock quantization parameter, and the final macroblock quantization parameter is calculated as:

$$Q_m = \left(\frac{d_m^n \times 31}{r} \right) \times N\_act_m$$

$$d_m^n = d_0^n + B_{m-1} - T_n \times (m-1) / MB\_CNT$$

$$r = 2 \times bit\_rate / picture\_rate$$

here, Q_m is the quantization parameter of current macroblock[[.]];

d_m^n is the current buffer occupancy, and it equals d_m^I,d_m^P , and d_m^b for I, P, B frame respectively[[.]];

B_{m-1} is the bits used to code previous macroblock[[.]];

d_0^n is the initial buffer occupancy for current frame[[.]], n is i,p or b, corresponding to

d_0^i,d_0^p,and d_0^b[[.]];

r is the size of virtual buffer.

Claim 12[[,]]. (currently amended) The method of claim 11, ~~as Claim 11 said,~~ wherein, when coding the first frame, the virtual buffer occupancy is initialized with:

$$d_0^b = K_b \times d_0^i$$

$$d_0^i = 10 \times r / 31$$

$$d_0^p = K_p \times d_0^i$$

here *r* is the virtual buffer size; d_0^i,d_0^p, and d_0^b is the initial virtual buffer occupancy for i, p, or b frame[[.]]; K_p is the complexity ratio between I, P frame; K_b is the complexity ratio between I, B frame.

Claim 13[[,]]. (currently amended) The method of claim 12 ~~as claim 2, 9, 10, 11 and 12 have said~~, wherein the RDO based rate control also includes a second RDO mode selection, after calculating the final quantization parameter for the current macroblock[[.]]; ~~That is to say,~~ thus the selected quantization parameter for the current macroblock will be used to do RDO mode selection again[[.]]; ~~The~~ the mode which minimizes the following expression will be selected as the coding mode for the current macroblock:

$$D(s,c,MODE \mid QP) + \lambda_{MODE} R(s,c,MODE \mid QP)$$

here, *s* is the luma value of the original macroblock[[.]], *c* is the luma value of the reconstructed macroblock[[.]], λ_{MODE} is the lagrangian constant[[.]];

~~For~~ for I/P frame, $\lambda_{MODE} = 0.85 \times 2^{Q_{m-1}/3}$;

~~For~~ for B frame, $\lambda_{MODE} = 4 \times 0.85 \times 2^{Q_{m-1}/3}$ [[.]];

D(s,c,MODE|QP) is used to evaluate the distortion of the current macroblock coded with mode *MODE*[[.]];

R(s,c,MODE|QP) is the bits used to code the macroblock with mode *MODE*[[.]];

QP is the quantization parameter for the current macroblock.

Claim 14[[,]]. (currently amended) The method of ~~as~~ claim 13 ~~has said~~, wherein for motion estimation in P or B frame, the motion vector minimizing following expression is

selected for the current macroblock:

$$J(m,\lambda_{MOTION}) = SA(T)D(s,c(m)) + \lambda_{MOTION} R(m-p)$$

here, *D(s,c(m))* is used to evaluate the distortion from motion compensation[[.]];

SA （*T*） *D* is the sum of the absolute difference (or after Hadmard transform) for the macroblock[[.]];

R(m-p) is the bits used to code the motion vector[[.]];

s is the luma value of the current macroblock in the original frame[[.]];

c is the luma value in reference picture[[.]];

m is the motion vector[[.]];

p is the predicted motion vector[[.]];

λ_{MOTION} is the lagrangian constant and $\lambda_{MOTION} = \sqrt{\lambda_{MODE}}$ [[.]];

λ_{MODE} is the lagrangian constant.

Claim 15[[,]]. (currently amended) An apparatus for ~~a~~ rate distortion optimization (RDO) based rate control ~~implementation includes following modules~~ comprising: a video coding encoder module comprising a JVT processing module ~~(for example, H.264 encoder module or JVT processing module)~~, ~~rate distortion optimization~~ a RDO mode selection and adaptive quantization module, a virtual buffer, and a global complexity estimation module;

wherein ~~here,~~ the JVT processing module receives ~~the~~ an input frame, and ~~it~~ is connected with the RDO mode selection and adaptive quantization module, the virtual buffer ~~module~~ and the global complexity estimation module[[.]];

the RDO mode selection ~~module~~ and adaptive quantization module is connected with the virtual buffer and the global complexity estimation module[[.]], ~~It~~ and is configured to receive ~~receives the~~ an input signal from the JVT processing module, and ~~processes it~~ to process the input signal based on the status of the virtual buffer ~~module~~ and the global complexity module ~~status~~[[,]];

bit allocation for every picture in a GOP which includes an I frame, a P frame, or a B frame is conducted, a first rate distortion optimization mode selection for every macroblock in the current picture using a predicted quantization parameter based on the allocated bits is conducted, wherein the predicted quantization parameter is the quantization parameter of a previous macroblock, and a coding mode minimizing the following formula as the initial coding

mode for the current macroblock is selected:

$$D(s,c,MODE\mid QP)+\lambda_{MODE}R(s,c,MODE\mid QP)$$

where s is the luma value of the original macroblock, c is the luma value of the reconstructed macroblock, λ_{MODE} is the lagrangian constant;

for I/P frame, $\lambda_{MODE}=0.85\times 2^{Q_{m-1}/3}$;

for B frame, $\lambda_{MODE}=4\times 0.85\times 2^{Q_{m-1}/3}$;

D(s,c,MODE|QP) is used to evaluate the distortion of the current macroblock after it is coded with mode *MODE*;

R(s,c,MODE|QP) is the bits used to code the macroblock with mode *MODE*;

QP is the quantization parameter for the current macroblock, and is equal to the predicted quantization parameter in the first rate distortion mode selection;

and the RDO mode selection and adaptive quantization module is configured to calculate a final quantization parameter for rate control using the information collected from the first rate distortion mode selection, and if the final quantization parameter is different from the predicted, execute a second rate distortion mode selection; ~~and then calculate the quantization parameter for the macroblock.~~

~~In the last,~~ the JVT processing module ~~will~~ is configured to output the final coded macroblock with the calculated parameter.

Claim 16[[,]]. (currently amended) The apparatus of ~~as~~ claim 15 ~~has said~~, wherein before coding a GOP, ~~does~~ bit allocation for the pictures in the GOP with the average picture size is conducted.[[;]]

Claim 17[[,]]. (currently amended) The apparatus of ~~as~~ claim 16 ~~said~~, wherein the average picture size is calculated as:

R/F = *R*÷*F*, here, *R* is the target bit rate[[.]], *F* is the picture rate[[.]], *R/F* is the average picture size.

Claim 18[[,]]. (currently amended) The apparatus of claim 17 ~~as claim 16 and 17 have said~~, wherein a ~~does~~ bit allocation adjustment in the GOP[[.]]is conducted, the ~~The~~ adjustment is shown as follows:

$$T_i = \max\left\{\frac{R}{1+\frac{N_p X_p}{K_p X_i}+\frac{N_b X_b}{K_b X_i}}, \frac{bit\_rate}{8\times picture\_rate}\right\}$$

$$T_b = \max\left\{\frac{R}{N_b+\frac{N_p K_b Xp}{K_p X_b}}, \frac{bit\_rate}{8\times picture\_rate}\right\}$$

$$T_p = \max\left\{\frac{R}{N_p+\frac{N_b K_p X_b}{K_b X_p}}, \frac{bit\_rate}{8\times picture\_rate}\right\}$$

here, T_I, T_p and T_b is the bits allocated ~~the~~ to the I, P or B frame respectively[[.]]; N_i、N_p and N_b is the remained none coded I, P or B frames in the GOP respectively[[.]]; X_i, X_p and X_b is the global complexity estimation for the I, P or B frame respectively and is defined as the multiplier between the coded bits and average quantization parameter for the frame[[.]];

bit_rate is the target bit rate[[.]], *picture_rate* is the frame rate[[.]];

K_p and K_b are constants[[.]], K_p, K_b means the complexity ratio between P,B frame and I frame respectively[[.]];

R is the remained bits for the GOP, and after coding a picture it is updated as follows:

$R = R\text{-}S_{i,p,b}$

$S_{i,p,b}$ is the coded bits for the current frame.

Claim 19[[,]]. (currently amended) The apparatus of claim 18, ~~as Claim 18 has said,~~ wherein before coding a GOP, the remaining bits for the current GOP is initialized as follows:

$$R = G + R_{prev}$$

$$G = bit\_rate \times N \div picture\_rate$$

here, R is the remained bits for the current GOP[[.]];

N is the number of frames in current GOP[[.]];

G is the number of bits for a GOP[[.]];

R_{prev} is the remained bits for the previous GOP[[.]], ~~For~~ for the first GOP, R_{prev}=0.

Claim 20[[,]]. (currently amended) The apparatus of ~~as~~ claim 18 ~~said~~, wherein X_i、X_p and

X_b are initialized as:

X_i=a×*bit_rate*

X_p=b×*bit_rate*

X_b=c×*bit_rate*

here a, b and c are constants[[.]];

bit_rate is the target bitrate.

Claim 21. (canceled).

Claim 22[[,]]. (currently amended) The apparatus of claim 15, ~~as claim 21 has said,~~ wherein for motion estimation in P or B frame, the motion vector minimizing following expression is selected for the current macroblock:

$$J(\mathrm{m}, \lambda_{MOTION}) = SA(T)D(s, c(\mathrm{m})) + \lambda_{MOTION} R(\mathrm{m} - \mathrm{p})$$

here, *D(s,c(m))* is used to evaluate the distortion from motion compensation[[.]];

SA （*T*） *D* is sum of the absolute difference (or after Hadmard transform) for the macroblock[[.]];

R(m-p) is the bits used to code the motion vector[[.]];

s is the luma value of the current macroblock in the original frame[[.]];

c is the luma value in reference picture[[.]];

m is the motion vector[[.]];

p is the predicted motion vector[[.]];

λ_{MOTION} is the lagrangian constant and $\lambda_{MOTION} = \sqrt{\lambda_{MODE}}$ [[.]];

λ_{MODE} is the lagrangian constant.

Claim 23[[,]]. (currently amended) The apparatus of ~~as~~ claim 22 ~~has said~~, wherein after the first rate distortion mode selection, the rate control scheme further includes: ~~Calculating~~ calculating a new quantization parameter and adjusting ~~it~~ the new quantization parameter according to the macroblock activity and buffer status.

Claim 24[[,]]. (currently amended) The apparatus of ~~as~~ claim 22 ~~said~~, wherein for adjusting quantization parameter for the current macroblock[[.]], the sum of the absolute difference is used

as the macroblock activity estimation after first rate distortion mode selection[[.]], and the ~~The~~ macroblock activity is calculated as:

$$act_m = \sum_{i,j} |s(i,j) - c(i,j)| \quad N\_act_m = \frac{(2 \times act_j) + avg\_act}{act_j + (2 \times avg\_act)}$$

here, i is the horizontal position of the pixel in the current macroblock[[.]], j is the vertical position of the pixel in the current macroblock[[.]], N_act_m is the activity of the current macroblock[[.]], $s(i,j)$ is the luma value of the original pixel(i, j), $c(i, j)$ is the prediction value of pixel(i, j)[[.]], avg_act is the average act_m in the previous coded picture which is coded with the same type as current picture[[.]], act_m is the sum of the absolute difference after motion compensation or intra prediction.

Claim 25[[,]]. (currently amended) The apparatus of ~~as~~ claim 22 ~~has said~~, wherein the [[a]] virtual buffer is used to do rate control[[.]]: first ~~First set~~ setting up the mapping from the virtual buffer occupancy to macroblock quantization parameter[[.]], the ~~The~~ macroblock quantization parameter is calculated as:

$$Q_m = \left(\frac{d_m^n \times 31}{r} \right) \times N\_act_m$$

$$r = 2 \times bit\_rate / picture\_rate$$

$$d_m^n = d_0^n + B_{m-1} - T_n \times (m-1) / MB\_CNT$$

here, Q_m is the quantization parameter of current macroblock[[.]];

d_m^n is the current buffer occupancy, and it equals d_m^I,d_m^P , and d_m^b for I, P, B frame respectively[[.]];

B_{m-1} is the bits used to code previous macroblock[[.]];

d_0^n is the initial buffer occupancy for current frame[[.]], n is i, p or b, corresponding to d_0^i,d_0^P,and d_0^b[[.]];

r is the size of virtual buffer occupancy.

Claim 26[[,]]. (currently amended) The apparatus of ~~as~~ claim 25 ~~said~~, wherein when coding the first frame, the virtual buffer occupancy is initialized with:

$$d_0^i = 10 \times r / 31$$

$$d_0^p = K_p \times d_0^i$$

$$d_0^b = K_b \times d_0^i$$

here r is the virtual buffer size; d_0^i,$d_0^{p,}$, and d_0^b is the initial virtual buffer occupancy for i, p, or b frame[[.]]; K_p is the complexity ratio between I, P frame; K_b is the complexity ratio between I, B frame.

Claim 27[[,]]. (currently amended) The apparatus of ~~as~~ claim 23, ~~24, 25, 26 have said,~~ wherein the RDO based rate control also includes a second RDO mode selection, after quantization parameter decision for the current macroblock[[.]], ~~That is to say,~~ thus the decided quantization parameter for the current macroblock will be used to do RDO mode selection again[[.]]; ~~The~~ the mode which minimizes the following expression will be selected as coding mode for the current macroblock:

$$D(s,c,MODE \mid QP) + \lambda_{MODE} R(s,c,MODE \mid QP)$$

here, s is the luma value of the original macroblock[[.]], c is the luma value of the reconstructed macroblock[[.]], λ_{MODE} is the lagrangian constant[[.]];

for ~~For~~ I/P frame, $\lambda_{MODE} = 0.85 \times 2^{Q_{m-1}/3}$;

for ~~For~~ B frame, $\lambda_{MODE} = 4 \times 0.85 \times 2^{Q_{m-1}/3}$ [[.]];

$D(s,c,MODE|QP)$ is used to evaluate the distortion of the current macroblock after it is coded[[.]];

$R(s,c,MODE|QP)$ is the bits used to code the macroblock with mode $MODE$[[.]];

QP is the quantization parameter for current macroblock.

Claim 28[[,]]. (currently amended) The apparatus of ~~as~~ claim 27 ~~said~~, wherein for motion estimation in P or B frame, the motion vectors minimizes following expression are selected as the motion vectors for the current macroblock:

$$J(\mathrm{m}, \lambda_{MOTION}) = SA(T)D(s, c(\mathrm{m})) + \lambda_{MOTION} R(\mathrm{m} - \mathrm{p})$$

here, $D(s,c(m))$ is used to evaluate the distortion from motion compensation[[.]];

$SA(T)D$ is sum of the absolute difference (or after Hadmard transform) for the macroblock[[.]];

R(m-p) is the bits used to code the motion vector[[.]]<u>;</u>

s is the luma value of the current macroblock in the original frame[[.]]<u>;</u>

c is the luma value in reference picture[[.]]<u>;</u>

m is the motion vector[[.]]<u>;</u>

p is the predicted motion vector[[.]]<u>;</u>

λ_{MOTION} is the lagrangian constant and $\lambda_{MOTION} = \sqrt{\lambda_{MODE}}$ [[.]]<u>;</u>

λ_{MODE} is the lagrangian constant.

Claim 29[[,]]<u>.</u> (currently amended) <u>The apparatus of claim 28,</u> ~~as Claim 28 said,~~ <u>wherein</u> quantization parameter from <u>the</u> RDO <u>mode selection</u> and adaptive quantization module is sent back to <u>the</u> JVT processing module, the macroblock is coded by <u>the</u> JVT processing module and output <u>of the JVT processing module</u>.